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ON THE EMERGENCE MECHANISM OF LUNAR MARIA

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ON THE EMERGENCE MECHANISM OF LUNAR MARIA

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SUMMARY

Various hypotheses are discussed with reference to possible mechanisms having created lunar maria. Several peculiarities of lava distribution rule out the "difffluence" mechanism from a central basin, i. e., lavas flooding maria and cirque floors can hardly originate from a unique center. On the other hand, it seems that the feeding channels are scattered about the entire area of a forming recession with thickening along its rims, these channels originating from a single source of which limit variants are discussed. The notion of a continuous, rather shallow fusion layer is introduced, suggesting the principle of connecting vessels. Comparison is made with conditions on Earth, where no such analogy can exist.

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There are several hypotheses on the origin of lunar maria and cirques. The most convincing of all is the opinion that maria and flat bottoms of cirques are composed of lavas, most probably of basic nature [12]. The peculiarities of distribution of these lavas along the area and in height have not yet been sufficiently explained.

The surfaces of Moon's young maria (lava areas) lack, as a rule, sufficiently sharp altitude gradients. They are either horizontal or smoothly bent, whereupon these drag dips are usually connected with general selenoid deflection from the true sphere [10, 14]. Apparently a significant fraction of this deflection occurs on account of surface curving of the gravitational potential [1]. In such a case a substantial part of maria is disposed horizontally relative to the gravitational field. However, within the bounds of each separate mare its surface may be considered as disposed over the same level. The protruding relics, of varying altitudes, only underscore this surface uniformity. At boundaries with continents these maria form complex bays, festoons, penetrating inside continental subsidences by meander lobes and entering craters. It seems that enormous masses of very liquid lavas ran over large distances from the central basin and flooded all the subsidences along their path. But to this "difffluence" mechanism from the center the following lava distribution peculiarities do not correspond.

1. Depressions on the outskirts of continents, filled with matter of maria, lie sometimes higher than the mare itself and the surface of the matter filling it rises somewhat toward the continent (Mare Nubium to the west of Alphonsus crater). But even if lava did spill, it should have moved from these depressions toward the mare and not vice-versa.

2. Locally, sea "channels" and "gulfs" are intertwined with continental areas into a labyrinth with narrow passages (region to the south of Taurus). It is difficult to believe that lavas are capable to run in such a way as to flood all these tortuous corridors.

3. The youngest dark lavas, well visible owing to the fact that they overlap the rays of Copernicus craters, are disposed without any sort of connection with the centers of mare basins; much rather to the contrary, they are confined to the edges of maria (Mare Serenitatis).

4. There is a multitude of small areas, each of which is bounded from all sides by continental crests and being nevertheless filled with matter of maria. At times one may see in a mare an annular wall of a cirque, of which the bottom is covered with mare overburden of same age as the matter of the surrounding mare. But this wall is nowhere interrupted, so that at times the way the mare substance hit inside the cirque remains incomprehensible. (Refer to Figs 1 and 2 of the plate next page). Still more surprising is the fact that mare surface level inside and outside the cirque remains the same. The same is observed also for depressions of irregular shape: the mare substance overlapping them has an identical or close level as compared with the adjacent mare, although each such area is isolated (Fig.3). Obviously, this is not a general rule, but much rather a trend; similar formations occupy an intermediate position between cirques in which the substance of mare is below the surrounding level and Wargentín-type cirques with excess of lavas. Similar phenomena are observed also for antique maria. Thus, the floor of Cyrillus crater, filled with ancient mare formations, lies at the level of surrounding localities, though originally this cirque should have had a depth comparable with the depth of the young Theophylus cirque. Between Alphonsus and Albategnius complex continental structures look as if they were immersed and flooded by dark-grey matter, whose surface maintains a unique level (Fig.4).

There are many such examples and the explanation, stemming from lava outflow from a single region, is inapplicable. Assumptions were ventured that the flooded areas emerged at continual melting from below, so that only floating "icebergs" of continental structures remained [13]. But in the midst of such a planetary melting the preservation of unique fault orientation in antemaria residual outcrops, just as in thin undistorted crater rings, was impossible. It is more probable that lava was fed to each separate "flooding" area along "individual" channels and cracks.

The localization of such feeding channels is of interest. According to "Ranger-9" photographs, 8 tiny craters were made apparent as fitted on cracks mostly along the rims of this caldera-like structure [12]. Each of them is

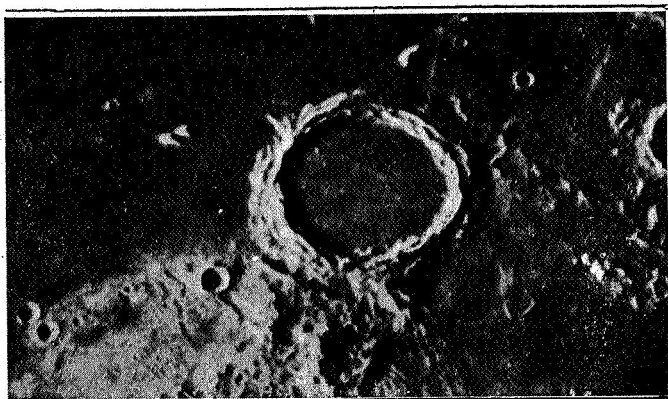


Fig.1. Archimedes cirque filled with mare substance

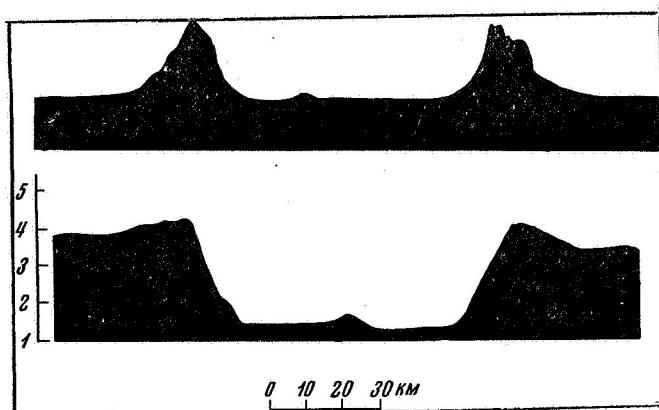


Fig.2. Archimedes cirque profile ante-maria (above)  
Copernicus cirque profile postmaria (below)

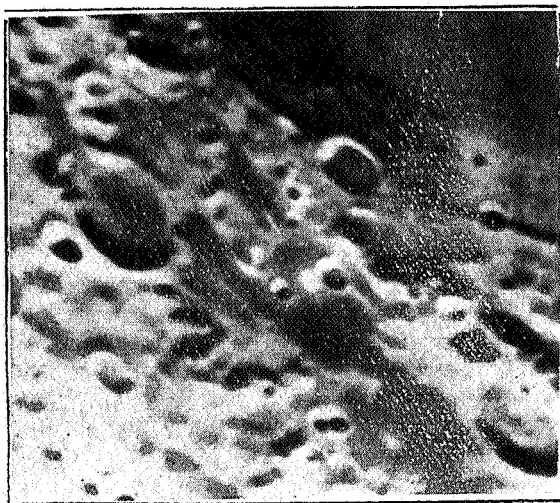


Fig.3. Mare Humorum shore. Dark lavas occupy the edge of mare basin and fill the subsidence between clear continental structures

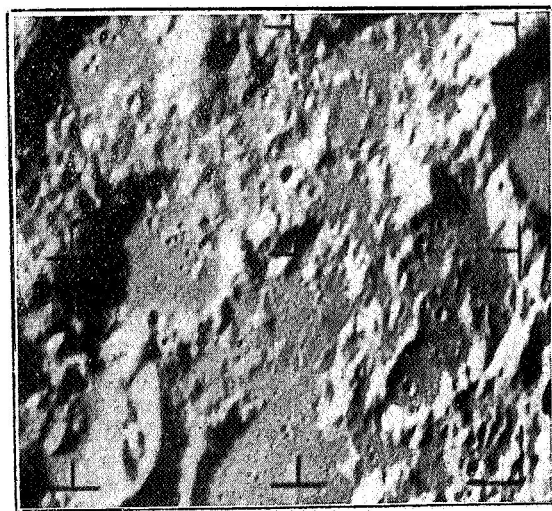


Fig.4. "Presunk" relief between Alphons and Albategnius (walled plain) cirques

surrounded by a dark spot of 5 to 10 km in diameter, formed by volcanic products of recent eruptions. The general sketch of cracks at the floor of Alphonsus crater bears witness on the irregularity in the subsidence of the entire bottom as a whole inside the annular wall. Seen on the cirque's wall are formations suggesting the lava "lakes" between Alphonus and Albategnius; namely, depressions with smooth bottom, partially bounded by concentric fractures of the wall. Similar lakes lie on the spurs of the internal slope of Copernicus wall [2]. Along the internal wall of Aristarchus crater a red band was observed; it was explained by lava effusion [11]. If these phenomena are indeed linked with effusions, one should conclude that the volcanic activity of similar cirques is localized in the zone along the cirque's wall. The fact that such shifts take place on the inner side of annular walls tends to explain numerous peculiarities of cirques. Thus, Sabina and Ritter craters reveal annular terraces shoulders and pits or ditches. In many cirques fractures form subconcentric structures (Pitatus, Arzachel). There are cirques in which pre-crater structures are seen inside the annular wall, whereupon they are lowered along the fracture passing along the edge of the floor. A significant part of subsidences, having given start to young maria, also occurred on account of shifts along the borderline faults. The ring of newest lavas encompassing Mare Serenitatis, the concentric walls and cracks of Mare Humorum, the escarpments of coastal mountain ranges - all this may be explained by the fact that weakened fissured zones pass along the edges of maria.

Therefore, lavas, flooding maria and floors of cirques, can hardly originate from a unique center. It is probable that their feeding channels are scattered about the entire area of the forming recession with thickening along its rims. But all these channels must be fed from a single source, for otherwise it would be difficult to explain the reason for their acting at one (geologic) time and forming lava shields at a single level.

There are two possible limit variants for such a source: 1) a fusion seam with small diameter, but deeply seated (at convergence of annular fractures on a cone with a 60 to 70° incidence angle the depth of a point source is comparable with the diameter of surface structure); 2) a not too deep fusion seam with diameter comparable with that of the surface structure. As regards caldera-like cirques both variants are possible. However, annular structures of maria have diameters of 300 to 600 km as an average, while a unique belt of maria extends across the entire visible hemisphere passing to the far side of the Moon. This is why the second variant is preferable for maria, that is, the fusion sources must have diameters of several hundred kilometers.

Therefore, the structure of the lunar surface (on the condition of its volcanic origin) provides the basis to assume that a continuous layer is disposed comparatively not too deep on the Moon, which if not a fusion seam, must be composed of matter readily prepared to melt at a small temperature increase or pressure decrease. If, for example, pressure should decrease under the action of tidal forces, a chain of fused seams of enormous extension must arise in the equatorial belt. The hydrostatic pressure, identical for the entire source, will ensure a relatively uniform supply of material

to the surface, resulting in the formation of unique plateau-basalts levels even in small isolated areas coinciding with the general level of maria. This mechanism suggests the principle of connecting vessels, but, obviously, in the most general form.

Such abundance and dimensions of fusion sources find themselves no analogy on Earth. Evidently, the fundamental cause of this difference consists in the lesser gravitational force and, correspondingly, in a pressure in lunar interior lower by a factor of 6. This is why in case of identical temperature distribution in depth, the melting point for the Moon will be attained at considerably lower depths than for the Earth [4]. Computations of possible temperature distribution for the Moon were performed more than once [5 - 8]. The initial data for these calculations can vary within broad limits. This concerns the age of the Moon, the content in radioactive substances, the means of their transport to the surface etc. Different are also the values of thermal flux used in computations, which are derived from observations in radio and infrared bands. Nevertheless, whatever the discrepancy in the temperature curves for the present time, they still intersect the curve for dunite fusion in the interval of depths from 250 to 600 km [8]. The melting of basalt must take place at lower temperatures [3], i. e., at 100 to 400 km depths. At the same time, if we postulate at the basis of calculations the data on the great thermal flux, currently contested [6], we obtain greater depths. One should also take into account the bearing out of radioactive substances into the solid shell by way of intrusions and effusions, which must raise the boundary of the fused layer. In any case, the available data on the thermal conditions of the Moon are not in contradiction with the presently stated representation on a beaded fusion layer, supplying the lunar surface with volcanic products.

\*\*\* T H E E N D \*\*\*

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